CRITICAL HEALTHCARE DATA MANAGEMENT USING BLOCKCHAIN TECHNOLOGY

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ABSTRAC

When the whole world is facing a crisis, there are people making crores of hassle-free money from the blood of innocent people. The red market, the term used for illicit organ trafficking, is flooding with demand for organs from people who can pay huge amounts of money. When thinking of how they get the victim whose organ will match the buyer's need, we found out that the medical records of the patients from the hospitals provide all those details. The so-called 'organ brokers' get access to the hospital's medical registry of patients either with or without their knowledge. Two major issues to be focused on in today's healthcare sector are data security and data ownership. Sensitive medical records currently lack a secure structure, resulting in data breaches with severe consequences. This can be overcome by our Blockchain Technology. Since blockchain was introduced through Bitcoin, research has been ongoing to extend its applications to non-financial use cases. Blockchain could maintain the patient's electronic health record and it provides a safer mechanism for health information exchange in the healthcare industry. Blockchain is nothing but a database where the data is typically structured in table format to allow ease of search and access of data. This new technology plays a major role in healthcare data maintenance. By using hyper ledger Composer, a blockchain-based Data Preservation System (DPS) for medical data has to be engineered. A DPS prototype has been designed and modeled after the Ethereum blockchain. The idea of applying blockchain in healthcare comes out of the need for security and interoperability in healthcare. The system includes storing and transferring the Medical health records of the users using the Ethereum Blockchain. The goal of our proposed framework is to first integrate blockchain technology for Electronic Health records and then to provide safe storage of electronic data for users of the framework by defining granular access controls. By establishing this system in multiple nations this health registry becomes Universal. By implementing the Blockchain in the maintenance of health records we have more benefits like accessing the records, transferring the data, report security, smart contracts verification, and so on. We provide a conceptual understanding of the technical foundations of the capability for blockchain technology in healthcare, that's essential to apprehend particular blockchain applications, compare commercial enterprise instances along with blockchain start-ups, or follow the discussion about its expected economic impacts. Consequently, this system of Universal Health Registry ensures security and ease of access to your medical records.

KEYWORDS: - Blockchain, Healthcare, Hyper ledger composer, Ethereum, Bitcoin.

INTRODUCTION

Blockchain is a digital ledger that acts as a database where all the data is stored with a unique hash value representing it, making it secure and easy to access. Every block in a chain has details of the transactions of data in it and every block is linked to another block using a unique hash value. Blockchain is a distributed and decentralized digital ledger that stores transactions in an ever-growing chain of immutable blocks linked by cryptographic hashes which gives an outline of how a Blockchain system works. Now, coming to the use of Blockchain in the Healthcare Industry, in healthcare we need to focus on both Data Security and Data Ownership. Currently, the medical records are not that much secured, which will result in Data Breaches with some serious consequences and medical crimes. In the year 2018, the Department of 'Health and Human Services' Office for Civil Rights (OCR) received notifications of many data breaches that resulted in the exposure of 13 million total healthcare records. According to a recent survey done on behalf of IBM Security by the Ponemon Institute, the average overall cost of a data breach in the United States was $7.91 million, with the health sector accounting for nearly half of that. Another issue is that patients do not have complete control over their medical data, which is becoming more and more important and prevalent. Both of these situations have substantial moral implications that must be addressed. In addition to these, demographic data such as age, gender, date of birth are very essential data that are needed to be secure. These data are required for maintaining a correct health record and treatments that are the need to be given for patients. These essential data can be misused by frauds for many purposes. These data can also be affected by other factors such as alteration, relocation, destruction, and so on. In recent years, a wide range of market sectors has attempted to incorporate blockchain technology's capabilities into their operations, demonstrating the technology's versatility. While the financial services industry has received the most of the attention thus far, various projects in other service-related industries, like healthcare, demonstrate that this is beginning to shift.

LITERATURE SURVEY

The analysis of the literature is split into multiple parts. We define how blockchain technology is used to help the healthcare industry. Blockchain [1] is treated as a ledger system that manages data and their transactions using time-stamped blocks through cryptography and works in a decentralized manner over the computing network. Although blockchain is originally used as a backbone for the cryptocurrency, Bitcoin, its capabilities and applications have yet to be extended far beyond cryptocurrencies. In this paper, through conducting the latest systematic literature review aiming to produce a new source of evidence, we identify potential applications of blockchain technologies in healthcare. The cost-effectiveness and efficiency of handling large volumes

of data have yet to be tested in production environments. Once the traffic increases, the transaction time can get long depending on the protocol; thus, impacting the scalability [2] and required computation power The transparency aspects make it difficult to protect data against malicious traffic analysis while maintaining accountability and transaction privacy [3]. Transitioning to blockchain technology in healthcare processes has some other problems.A sufficient amount of training is required for healthcare providers and patients. Users have to be trained on how to design and manage the distributed controllers and network functions to ensure vertical and horizontal scalability, and [4] how to autonomously orchestrate network functions and services across the software middleware.The idea of applying blockchain in healthcare comes out of the need for security and interoperability in healthcare. With the evolution of IoT and the abundance of health devices and mobile healthcare applications, a considerable amount of medical data is recorded and transferred every day. This data traffic needs management regarding privacy and security. Blockchain technology can provide a solution that not only helps to secure recording and sharing of medical records but also assures the privacy of each patient's data by giving the patients their medical data ownership. Besides the advantages of blockchain for healthcare management, its challenges should be met in advance [5].

INFERENCE

Blockchain technologies have the potential to improve several aspects of healthcare and well-being. This paper discusses recent developments in pharmaceutical traceability, data sharing, clinical trials, and device tracking.

1. KEY FEATURES OF BLOCKCHAIN

1.1. TRANSPARENC

After giving access to our data, we cannot see who is accessing it nowadays. A lot of discrepancies could happen due to this as we have almost no control over our data. Blockchain implementation not only enables transparency of our data but also ensures complete privacy over our data. This is one of the main reasons why blockchain must be implemented especially in government systems. We can also trace and track whoever accesses our data and also invoke their permission if we feel they are not handling our data properly. For example, when we go to a hospital, we explain our issue to the receptionist, later it is made into a report which is later on given to the physician for verification, later to the lab technicians, then to the pharmacist, and the insurance companies if the patient opts to pay through their insurance. In all these cases there are high chances that our report may be leaked for misuse by various illegal purposes. The higher the number of persons getting access to our data, the higher is the risk of our data getting leaked. This can be avoided when we implement a blockchain in hospital networks. When this is done, the report can be accessed only with the consent of the patient.

1.2. DECENTRALIZATION

Data is the new oil says Clive Humby, recent data breaches show us that this statement is more than true. Many companies use our data as a business and earn millions of dollars. Hence when data breaches happen in those companies, it is our problem too as the data being leaked and misused is ours. This happens only because a single central firm is holding possession of our data. This centralization is broken by employing blockchain technology in any field as it involves the storage of data in the thousands of nodes around the world that are connected to the network. In the same hospital scenario, hospital management may share our data with their partner companies for any promotion and other purposes. When blockchain is implemented our data cannot be shared by the hospital without our acknowledgment. This ensures decentralization where data is not in a single hand but is scattered around thousands of nodes in the network around the world.

1.3. DATA PROVENANCE

Data provenance is another important aspect that must be implemented in the healthcare industry as data traceability would ensure a great amount of trust among the hospital and the patient. The feature to trace our data, who and when our data is being created, edited, and deleted gives us peace of mind that we have control over our data. Moreover, blockchain technology involves timestamping the data and the changes made to it and stores all the available versions of the data. When our medical reports are sent to different people there is a possibility that they may be edited. Data provenance ensures the data from being accessed and altered by unauthorized users.

1.4. IMMUTABILITY

The data we store has a high chance of being altered by anyone who gains access to it. The key blockchain feature immutability prevents this as we can provide different access permissions to different users. Also if someone tries to access and alter the data, they would have to alter all the blocks in the chain whose hash value will change in turn which requires an infeasible amount of time and computational power to alter. Hence the immutability of data is ensured in blockchain-based systems.

1.5. CONSENSUS AND DISTRIBUTED LEDGER

The consensus algorithm is another important aspect of blockchain that involves the query function in blockchain where a query can be sent when someone like the doctor, pharmacist, lab technician, insurance agent, etc. wants to access the patient's report. This request can either be accepted or invoked by the patient. Hence the consensus algorithm ensures the authenticity of the transaction. Distributed Ledger on the other hand reduces the mishandling of data in the network by properly verifying and validating the transactions and storing them with a timestamp which is useful for accessing the data based on the date and time it was created. Also, since blockchain is auto-upgrading, the data is consistently in synchronization thus having all versions of the data with the date it was altered. Consensus along with distributed ledger makes the data in the blockchain easily accessible for administrative purposes.

1.6. PROGRAMMABILITY AND ANONYMITY

Programmability is the feature that facilitates the automatic initialization of transactions between the nodes in the peer-to-peer blockchain network where the smart contracts are used to initiate a transaction automatically when a certain condition becomes

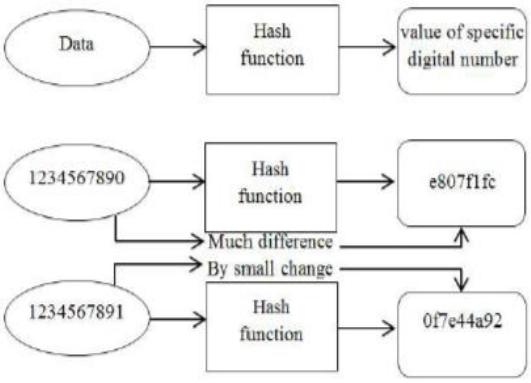
true. These transactions ensure traceability and establish trust when two anonymous people are transacting without involving a third party. When two parties transact, their identities will not be visible to everyone hence ensuring a seal of anonymity.

2. PROPOSED SYSTEM

The proposed system includes storing and transferring the Medical health records of the users using the Ethereum Blockchain. This can be as secure as transacting through consensus blockchain and more affordable. By implementing smart contracts on the Ethereum blockchain, the patient-provider relationships can be logged in a database that associates the medical records with permissions for viewing and retrieval of data instruction (essentially data pointers) for execution on external databases.

Figure 1: Generating Hash value

A cryptographic hash on the record will be implemented on the blockchain to ensure the protection against tampering, which guarantees the integrity of data. Whenever the hospitals add new records to the patient's database the patient will be notified and he/she should be authorized to share the data with another hospital or pharmacy or insurance firm by creating a private key. The receiver also gets a notification and can verify the authenticity of the record using a public key (generated using a private key using complex mathematical operations) before accepting or rejecting the transaction. When the patient sends or receives their record, they can have a full track of who is accessing the records.



Usability is prioritized by smart contracts which combine the references of all patient-provider transactions and provide a single point of reference that can be used to check new updates on the medical history of the patient. Confirmation of identity can be done via public key cryptography that enables a DNS implementation that can be mapped with a reference ID to the patient's Ethereum address. The data exchange between the patient and the provider is implemented by using a syncing algorithm, and the confirmation of permission is done via a database authentication server after the referencing of the blockchain.

2.1. DESCRIPTION OF THE SYSTEM COMPONENTS

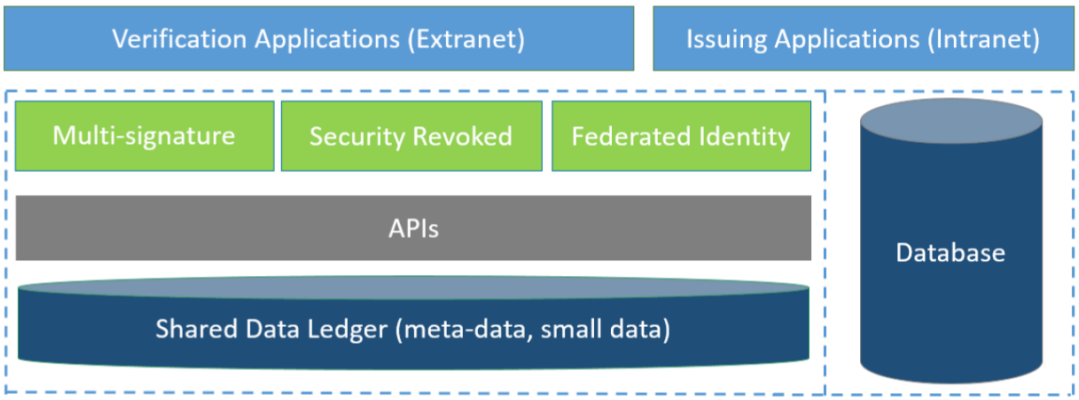


Figure 2: System Architecture or Proposed system

The design of the system contains two primary nodes between which the transaction happens and this model can be substituted in all the situations that require the transfer of data. We have to consider that the two nodes, namely the provider node and the patient node, have a well-managed database to store the records sent or received. The four components namely Backend library, Ethereum client, Database Gatekeeper, and EHR Manager are the main software components. The backend and user interface

implementation has to be done by the provider that can employ the interoperability protocol as defined in the smart contracts. Backend API Library contains a bundle of multiple utilities that facilitate the operation of the system. The library handles the communication with blockchain and ensures the export of function-call API. The hurdle of working directly with the blockchain will be avoided by the Applications that manage the record and their user interface is built as such. Another major issue is keeping track of whether the transaction is accepted or not and this is handled by the library as well by interacting with the Ethereum client thereby ensuring the parsing of the Ethereum protocol and low-level formatting. The complete interaction with the Ethereum blockchain network is implemented using the Ethereum Client. It handles a series of preliminary tasks like connecting to the network of peer-to-peer clients, encoding and transporting transactions, and verifying the local copy of the blockchain.

The implementation of the interface of access to the local database of the node is done by the Database Gatekeeper in an off-chain manner. A server of this Gatekeeper stores and runs the request queries from the clients on the network. This request contains a string of queries merged with a reference to the data that handles the permissions and authentication. This request is then signed cryptographically by the provider later to be verified by the gatekeeper for identity confirmation. As soon as the signature of the provider is confirmed, the gatekeeper starts verifying the Ethereum address and verifies whether the query is genuine. If the query is genuine the transaction proceeds otherwise it returns to the node of the client's local database All the above components are integrated into the EHR Manager and the application's user interface. The application gathers data from the local database and facilitates viewing and providing the updates through notifications also helping in sharing and retrieval of data.Apart from these components, an Ethereum exclusive feature called smart contract is used to facilitate the hassle-free data transfer between the patient-provider Ethereum addresses. These smart contracts have different structures of which three are used.

2.2. STRUCTURE OF THE SMART CONTRACTS

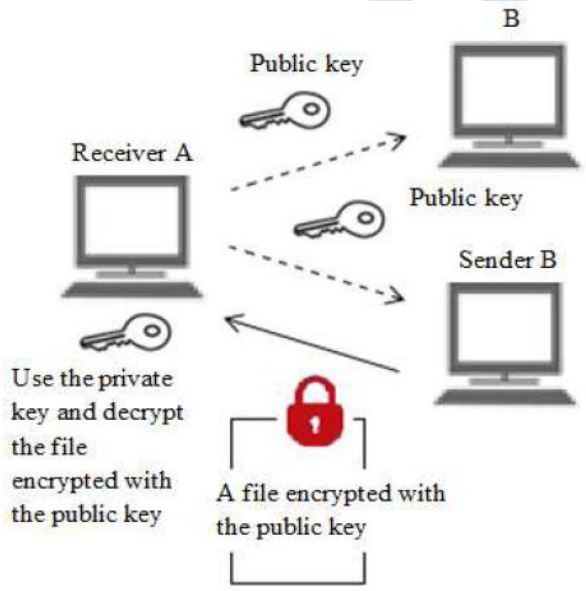


Figure 3: Private key and public-key cryptography

Registrar contract is used to identify and verify the Ethereum address of the patients in the network. The contracts are coded with policies that facilitate registering new identities and editing the already existing ones and removing the old ones as well. Hence the registration of identity is restricted to only certified Ethereum addresses. It also uses identity strings instead of public-key cryptography to allow the use of pre-existing forms of identification and also connects to addresses on the blockchain using another contract called Summary Contract. The patient-provider relationship contract is the contract that manages all the interactions between the provider node and the patient node. Here it ensures the data storage of data in one and management of the records in the other which ensures the patient's absolute control over the data and also the integrity of the data. It also manages a pointer that associates the access permission, verifies and locates the stored records on the database of the provider. It also keeps track of sending and receiving the query request for accessing the records either by patients or the third parties approved by the clients. Furthermore, it executes the queries by verifying the authenticity of the transaction and the Ethereum address from which the query is received. Summary Contract, this contract helps in locating the history of a patient's medical records. It also keeps track of all the interactions between the patient-provider nodes, having all the details about the patient's current and previous interactions. The summary contracts of patients would contain all the interactions with the different provider nodes they are engaged with. In the case of Providers, their summary contracts have the data of all the patients they interact with and the third parties their patients have given access to. The summary contract keeps a clean stack of data of all those interactions in the distributed network between the patient and the provider. It also manages to secure the data from data loss by securely backing up and restoring the data in the distributed network. For a limited amount of time, the patients can leave and rejoin the network but will always have access to their history of transactions when they download the latest blockchain version from the network. The blockchain log will be present as long as the provider node is present in the network whose withdrawal is rare in most cases.

Various user-friendly features like providing user notification and giving status updates can all be limited or turned off if the user finds it annoying. Patients can also manage their relationship with the provider nodes accepting, rejecting, deleting existing relationships, deciding to acknowledge the access to their history thus ensuring the patient's full control over their data.

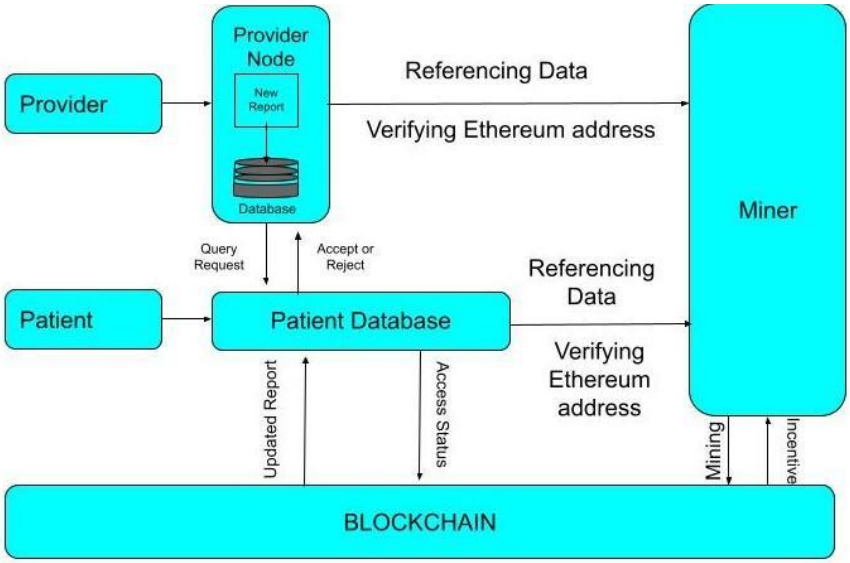


Figure 4: Process of transaction in the proposed system

When adding the record of the new patient from the provider node, the Registrar contract, a global contract that links the participant identification to their Ethereum address in the blockchain is used. Then a query for referencing the data is created and the reports are updated accordingly. Now that the data is referenced and the Ethereum address is verified, the report is sent in the form of a transaction by the provider node to the patient's Summary contract, a contract that allows easy identification of the data from the database and to locate it.

As a next step, a new block is mined by the miner causing a signal that will send the notification to the user. Now, the user either accepts or rejects the transaction with the provider which is updated in the Summary contract accordingly. If it is accepted, a query is implemented to obtain the new report which uses the information from the summary contract to locate the provider database, identifies and retrieves the report.

Now, the patient receives the notification and accepts it. They can also share their data with a third party, this can be done by sending a query to the third-party's Ethereum address and they can choose whether to accept or reject the transaction similar to the patient. As a result, the address may keep changing but the process of the transaction remains similar for different nodes. Furthermore, the data access can be done either on a Website exclusive for the patients or through DAPPs (Decentralized Applications) that run on the Ethereum blockchain. The encryption features include requesting an authentication code from an authenticator app for both logging into the app and accessing the record.

2.3. BENEFITS OF THE PROPOSED SYSTEM

2.3.1. Access to records:

Nowadays people visit the hospital often for different kinds of problems that they lose tracks of which report they should provide to the new physician they visit. Also, they might not have access to their previous reports. This may put them at risk of taking a medicine that may not be compatible with the medicine they are under currently. In the proposed system of Universal health registry using blockchain, they can give one-time access to their doctor so that they can provide a precise diagnosis.

2.3.2. Transfer of reports

Whenever we want to do an online consultation or provide our medical reports to an insurance company or share them with the companies we work for a medical claim, we may find it difficult to transfer our medical reports as many hospitals will not share our reports even with us. But in our proposed system every hospital we visit adds our medical report to the blockchain database from which we can access it anytime.

2.3.3. Security of Reports

Most of the crimes like organ trafficking happen due to the data breach in the hospital's server or the hospitals voluntarily giving out our medical records for money. Also, some people may like their diagnosis report to be secured as they don't want others to know their medical condition but anyone can walk into a hospital and get the report by using their patient ID. But in the proposed system none of the above are possible as the technology is Blockchain which is a decentralized network of computers around the world. A data breach is impossible as your data will be scattered in thousands of computers around the world. The access is limited to only the patient or the people, the patient consents to give access to.

2.3.4. Smart contracts

As mentioned above, the usage of Ethereum blockchain gives us an exclusive feature called 'Smart Contract'. Smart contracts ensure security and have a verification system that rarely fails. It has separate systems for referencing the data, verifying the Ethereum address of and sending queries either to accept or reject the transaction.Also, a feature called 'Proof of stake' which allows only a single node to complete a transaction to add it to the block reduces the cost of a single transaction by a considerable amount compared to the transactions in other forms of blockchain technology. Also, it ensures if the node cheats in completing the transaction, it will be punished a considerable amount of fine in Ethers which makes a huge sum of loss if the node wants to cheat. As a result, the completion of the transaction is ensured.

2.3.5. DAPPs and DeFi

There are numerous health apps and every hospital uploads its reports in its partner apps. So we need to download many such apps if we are undergoing more than one or two treatments. This will be annoying. Also, most of the apps won't be maintained and will be down so that we cannot access our reports through it for our urgency. This can be eliminated by the exclusive feature of Ethereum called 'DAPPs' which is nothing but Decentralized Applications. Since these are not maintained by a single company, all the hospitals using the proposed system may upload the reports in the same Dapp from which the patients can access their reports anywhere anytime. Also, these Dapps have no downtime as they run on a chain of thousands of computers so even if one computer in the chain stops working other computers will ensure the easy access and functioning of the Dapps.Many finance companies are there offering attractive insurance plans but only during a medical emergency, we come to know how slow they are in processing the funds and also that the insurance plans cover only their partner hospitals. To eliminate this issue another Ethereum exclusive feature called ‘DeFi’ can be used. DeFi means Decentralized Finance and since it is decentralized we can buy insurance policies that can be used in every hospital that uses the proposed system of medical health registry. Since it is fully based on Ethereum, it ensures safety, security, easy access, and easy claiming in case of an emergency.

3. ADDITIONAL USE CASES

Apart from the healthcare, blockchain can also be used to improve the functionality of the streamlined fields of healthcare. These are major developments concerning these fields but when implemented they can be used to reduce a lot of errors in these indefinitely important in the following fields:

3.1. IMPROVEMENT IN DRUG TRACEA

The result of discrepancies happening in the drug field is often as worse as fatality. When a drug is manufactured, it has to move to a warehouse where it is stored till transported to the distributors who sell them to retail stores. In this process, there are high chances of the drug getting spoiled or expired, or even being stolen. Traceability is a major concern here, the absence of which makes a huge loss for either the people earning from it when it's stolen or for the consumers when it is spoiled or expired and it leads to any side effects. Also, the replacement of fake medicine for the real ones is the worst nightmare for the consumers who are in definite need of expensive medicines for their illness. It is estimated over $200million of drugs are being stolen in exchange for fake drugs that end in the hands of innocent patients who pay huge sums for them. Blockchain implementation in this field is a gift to the end consumers as there is a ledger that stores every movement of the stock right from the factory to the customer. Also, it can turn out to be a convenient way for the distributors and retailers to check whether their stocks are available incorrect amounts. Since the transactions are timestamped, the drug could be supplied to the consumers before it gets spoiled or expired. Hence the technology proves useful not only for digital transactions but also in the exchange of physical commodities.

3.2. BILLING SYSTEM

Many private health centers don't follow the government pricing for in-demand drugs and medicines. They often hike prices or even double the price that is fixed by the government. These happen due to a lack of a proper billing system and also since these hospitals are centralized and operate on their own rules. When blockchain is implemented in the billing system, it is ensured that all the hospitals in the network have a similar price that is fixed by the government. This could also mean that the cost of many treatments could reduce to a considerable amount resulting in the affordability of treatments even in private hospitals.

3.3. ORGANS AVAILABILITY

It is known that the availability of organs is in huge demand as our lives are in an unhealthy environment for centuries. Hence, the organ failure rate has increased right from children to old people. Due to the demand for organs, they have to wait for long periods to get organs for their transplant from a donor. This is where money-preying organ brokers come into play. They target poor people who need money for the treatment of their families, brainwashing them to donate their organs. They sell these organs in the red market which is the term used for a market where rich impatient people with organ failure pay huge sums for the organs they get from the organ brokers. The ratio of money given to the poor and the money these organ brokers receive from the rich will have a huge difference. Hitting the poor in their worst situation is the worst a fellow human being could do to them but no one cares about this apart from the fact that it is a punishable offense. The main reason for this problem is some hospital staff or even the hospitals are giving out the information of their patients to these organ brokers for money. They even sell organs for a better price to the organ brokers. This would be a betrayal for thousands of people who are counting their days hoping they would get a donor. This happens mainly due to the lack of a proper record system in the organ banks. When blockchain is implemented, the organ banks could trace details like who is the organ donor, where the organ is going, and who is receiving the organ. Also, a detailed list of who are all handling the organ is stored in the blockchain. This could be a great relief for those whose chance of survival is rebuked suddenly due to the organ brokers.

3.4. RESEARCH AND DEVELOPMENT

A lot of affordable medicines are being developed by researchers and scientists every day. The only reason why they don't reach people is the huge pharmaceutical companies getting their patents either for money or forcefully. These medicines could prove to be very useful for patients who are in poverty conditions. Even substitute medicines that can be given at low cost are not reaching the common people due to the dominance of the pharmaceutical companies who are MNCs operating in multiple countries around the world. The main reason for this problem is that the patents of the scientist are either rebuked or shown as not at all filed. This can be overcome by implementing blockchain technology in patent filing where the scientists could send their research to the government and file patents. This method could show how independent scientists could bring affordable medicine into the system. Moreover, many scientists and research could operate individually without the pharmaceutical companies overshadowing them.

4. INDUSTRIAL IMPLEMENTATIO

We do not suggest our proposed system as the only solution in the healthcare industry or the only blockchain system for storing and transferring the patient's medical records. Our motive is to suggest how such a system could help the healthcare sector and the patients paving to the global healthcare priorities. As a part of the blockchain community, we hope our system will give an organized structure of an electronic healthcare registry. Moreover, our proposed system will be a convenient system for the patients' right from visiting hospitals to ordering medicines, switching doctors, and visiting hospitals in case of emergency when they are traveling and also in buying insurance policies. The system gives the patients a long-term record of their health records. We also hope our system will be implemented along with the gadgets like smartwatches people use in large numbers nowadays. Patients can have a sectioned arrangement of their medical data and can share them with the physicians for a precise diagnosis as the physician can see whatever the patient had been treated within their past. We can also use our system in predictive analytics as the patient's history can be used to predict the possible health problems the patient might face and this will help them make changes to their lifestyle, food, working places accordingly. Integrating our system with technologies like machine learning and data analytics for precise prediction. It can also alert the physicians if prescription access is abused in buying and misusing scheduled drugs. This will also help in controlling narcotics abuse paving way for a reduced misuse of drugs.The system can also be used for research purposes with the consent of the patients by collecting insightful, community-wide data on the treatments expected by people thus helping to achieve goals in the fields of precision medicine and research based on evidence. This will facilitate the outcomes for research institutes that are patient-centered providing effective clinical research. As all the data of the patient's healthcare data is available in a proper arrangement, predicting and giving medicines as a preventive measure can be taken effectively. These methods can reduce the number of research trials that include expensive procedures for producing new medicine as the data of long history is already in hand. This system serves as the supportive directory for healthcare records and resources that are secured by public-key cryptography and ensures data accessibility and data integrity. This blockchain directory model supports the ability to "grow and change dramatically throughout its lifetime— adding new participants and changing organizational relationships" through stateful updates to the smart contracts [6]. The fundamental aim of our system is to enable the ease of access to their medical records for the patients thus enabling giving them a holistic understanding of their current health status without involving a centralized data repository. We also strive to enable precision medicine for the better diagnosis of the patient's concerns thus enabling a healthy future for the upcoming generations.

5. CONCLUSION

We introduced blockchain technology in this paper, which is well-known for its use in cryptocurrencies but has a larger range of applications too ranging from banking to healthcare. Since 2012, there has been a lot of blockchain research. However, blockchain integration in healthcare is a relatively young and rapidly growing field. With its revolutionary approach to decentralized administration, robustness, security, and an indelible audit trail, the blockchain is positioned as a paradigm shifter. Early blockchain applications in healthcare have demonstrated that it is not only transforming technology, but also a method of

conducting business, rethinking the relationships between players ranging from healthcare professionals to patients, pharmaceutical companies to scientists. There are also certain worries with blockchain technology, which necessitates further investigation. The main technical concerns to be addressed are transparency, confidentiality, speed, and scalability. Legal and regulatory issues must even be addressed. Before implementing blockchain in the healthcare system, feasibility studies using a system of systems approach should be conducted. Because it covers all three dimensions of people, process, and technology to create a holistic view, the system of the systems approach is the most important approach for feasibility studies.

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